SCIENCE

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THE ORGANIZATION AND WORK OF THE BUREAU OF STANDARDS.

THE Bureau of Standards was organized July 1, 1901, as one of the Bureaus of the Treasury Department, and Professor S. W. Stratton, of the Chicago University, was appointed director. On July 1, 1903, it was transferred along with certain other bureaus to the newly established Department of Commerce and Labor.

The functions of the Bureau of Standards are briefly stated in the act of congress by which it was established. The bureau is to acquire and construct when necessary copies of the standards adopted or recognized by the government, their multiples and subdivisions; to make accurate comparisons with these standards of instruments and standards employed in scientific investigations, engineering, manufacturing, commerce and educational institutions; to conduct researches pertaining to precision measurements and to determine the physical constants and properties of materials. The bureau is also to furnish such information concerning standards, methods of measurement, physical constants and the properties of materials as may be at its disposal, and is authorized to exercise its functions for the government of the United States, for state or municipal governments, for scientific societies, educational institutions, corporations, firms or individuals, and although not expressly authorized in the act referred to, sometimes also serves foreign governments. No fees are collected for services performed for the national or state governments. From others a reasonable fee is charged, and a

new schedule of fees has recently been published.

To carry out these functions adequately requires large, well-equipped and fully manned physical and chemical laboratories. To this end congress has appropriated $25,000 for a site, $325,000 for two buildings and $225,000 for apparatus and equipment. It is expected that the buildings will be finished and their equipment of apparatus and machinery installed during the present year. These buildings have been so planned and located that additional buildings may be added as they become necessary.

In the meantime, while the work of planning and building laboratories and designing and constructing the somewhat extensive and in many respects unique equipment of the same has been going on, the bureau has been effecting its organization and developing its work in temporary quarters. When the Bureau of Standards was organized it superseded the office of Standard Weights and Measures and acquired its equipment; the old offices in the Coast and Geodetic Survey building were retained, and by the courtesy of the superintendent of the Coast and Geodetic Survey, several additional rooms provided in the adjoining building. A year later a neighboring residence was rented and converted into a laboratory and instrument shop. In the brick stable at the rear of the house a gas-engine and dynamo were installed for charging a storage battery, the latter being located in the laundry; the kitchen became the carpenter and cabinet shop; in another basement room were installed a switchboard and several motor-driven alternators. The parlor and dining-room were taken for an instrument shop, and here four mechanicians and two apprentices turned out some very important pieces of apparatus, in most cases, of course, of special design that could not be purchased already made. The three floors above have been occupied as laboratories.

In these very inadequate quarters the bureau has not only gathered together a considerable equipment of apparatus and done a great deal of preliminary work, but it has also done some testing for the government and the public and not a little research. The quantity of testing done has been limited partly by an insufficient force of assistants, partly by the incomplete equipment of apparatus and partly by lack of space in which to set up apparatus already at hand. It is the intention to undertake nothing in the line of testing that can not be done well. In some cases, however, instruments and standards submitted have necessarily been retained a considerable length of time. In every case, however, the bureau has striven to complete all tests requested as promptly as consistent with satisfactory results. During the present preparatory stage of the bureau the time required is often much greater than will be the case after the work is well established.

THE ORGANIZATION AND PERSONNEL.

The act establishing the bureau provided for fourteen positions at an aggregate salary of $27,140. The next year (1902–3) the number was increased to twenty-four at an aggregate salary of $36,060. For the present fiscal year there are altogether in the bureau fifty-eight positions at an aggregate salary of $74,700. These positions are as follows:

One director, one physicist, one chemist......	3
Eight assistant physicists, one assistant chemist	9
Fifteen laboratory assistants, one librarian, one computer, one draftsman................	18
One secretary, four clerks, two messengers, one storekeeper	8
Four mechanicians, two woodworkers, three apprentices, two laborers..................	11

One engineer, one assistant engineer, one electrician, two firemen, two watchmen, one janitor, one charwoman..................	9
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Thirteen additional positions will be available for the next fiscal year. All positions in the bureau are filled through the civil service commission, in many cases as the result of special civil service examinations. An erroneous idea is more or less prevalent that even scientific appointments in the government are made on the basis of personal or political influence. Nothing could be further from the fact. The officers of the bureau have been free from any such pressure and in every case they have striven to select the best man that was available for any given position. These positions are permanent, the civil service commission affording ample protection against loss of position without sufficient cause. Thus, while the interests of the government are protected on the one hand, the interests of the servants of the government are guarded on the other; and while the machinery of selection sometimes seems ponderous and appointments are often considerably delayed, it would be difficult to conceive other methods that would accomplish what the civil service actually does accomplish without equally serious objections of one kind or another.

For convenience of administration the bureau has been divided into three divisions. Division I. is under the personal charge of the director; Division II. is under the charge of the writer; and Division III. is under the charge of the chemist, Professor W. A. Noyes.

DIVISION I.

Division I. comprises six sections, as follows:

1. *Weights and Measures,* under the charge of Mr. L. A. Fischer (Columbia University), who was for many years connected with the office of Standard Weights and Measures. He is assisted by L. G. Hoxton (University of Virginia), R. Y. Ferner (University of Wisconsin), N. S. Osborne (Michigan School of Mines) and L. L. Smith.

2. *Heat and Thermometry,* under the charge of Dr. C. W. Waidner (Johns Hopkins University), assisted by Dr. G. K. Burgess (M. I. T. and University of Paris) and Mr. H. C. Dickinson (Williams and Clark University).

3. *Light and Optical Instruments,* under the personal charge of the director, assisted by Dr. P. G. Nutting (University of California and Cornell) and Mr. F. J. Bates (University of Nebraska).

4. *Engineering Instruments,* under the charge of Mr. A. S. Merrill (M. I. T.).

5. *The Office,* under the charge of the secretary, Mr. Henry D. Hubbard (University of Chicago), assisted by Dr. J. R. Benton (Cornell), librarian, Mr. D. E. Douty (Clark University), storekeeper, four clerks and two messengers.

6. *The Instrument Shop,* with Mr. Oscar G. Lange, chief mechanician, and three other mechanicians and two apprentices, and the woodworking shop with two woodworkers.

DIVISION II.

Division II. comprises six sections, as follows:

1. *Resistance and Electromotive Force,* under the charge of Dr. F. A. Wolff (Johns Hopkins University), assisted by Mr. F. E. Cady (Massachusetts Institute of Technology) and Dr. G. W. Middlekauf (Johns Hopkins University).

2. *Magnetism and Absolute Measurement of Current,* under the charge of Dr. K. E. Guthe (University of Marburg, University of Michigan).

3. *Inductance and Capacity,* under the personal charge of the physicist, assisted by Dr. N. E. Dorsey (Johns Hopkins Uni-

versity) and Mr. F. W. Grover (Massachusetts Institute of Technology and Wesleyan).

4. *Electrical Measuring Instruments,* also under the personal charge of the physicist, assisted by Dr. M. G. Lloyd (University of Pennsylvania), H. B. Brooks (Ohio State University), C. E. Reid (Purdue) and F. S. Durston (Wesleyan).

5. *Photometry,* under the charge of Mr. E. P. Hyde (Johns Hopkins University).

6. *Engineering Plant,* under the charge of the engineer, Mr. C. F. Sponsler (Pennsylvania State College).

DIVISION III.

Division III. comprises the chemical work of the bureau. At present the personnel of this division includes, besides the chemist, only the assistant chemist, Dr. H. N. Stokes (Johns Hopkins University). This work is relatively late in its organization, for the reason that the bureau has no place in which to develop a chemical laboratory. Plans are being matured the present fiscal year, and as soon as the new buildings are ready a complete chemical laboratory will be installed in one of them.

Through the courtesy of President Remsen, Professor Noyes is doing some work this year in the chemical laboratory of Johns Hopkins University; and through the courtesy of Dr. Wiley, of the agricultural department, Dr. Stokes is doing some work in the chemical laboratory of the bureau of chemistry. We expect to see some additions to the chemical force at the beginning of the next fiscal year.

THE VISITING COMMITTEE.

In naming the personnel of the bureau, I must not omit to include the visiting committee, constituted as follows: President Ira Remsen, Johns Hopkins University; President Henry S. Pritchett, Massachusetts Institute of Technology; Professor Edward L. Nichols, Cornell University; Professor Elihu Thomson, Lynn, Massachusetts; Mr. Albert Ladd Colby, Metallurgical Engineer, Bethlehem, Pennsylvania.

These gentlemen meet in Washington at least once each year, and after receiving a report from the director, make a thorough examination of the work of the bureau. On the basis of this examination they present a report to the secretary of commerce and labor, making such recommendations as they think proper. This committee has already been of much service to the bureau, and it is believed that it will also serve a valuable purpose as a medium of communication between the scientific public and the bureau.

The director of the Bureau of Standards renders an annual report and submits his estimates of the needs of the bureau to the secretary of commerce and labor. Through him congress receives these estimates and grants specific sums for buildings, for equipment, for current expenses and for salaries, after the director has appeared before the appropriations committees of both houses and explained in detail the needs of the bureau and the work to be carried on with the money appropriated.

THE SCIENTIFIC WORK.

The scientific work and testing which the bureau is doing at present or for which preparations are in progress may now be briefly stated.

DIVISION I.

SECTION 1. *Weights and Measures,* including the determination of lengths, masses and volumes.

The bureau possesses at the present time two iridio-platinum copies of the international meter, to which all lengths are referred, and apparatus for comparing other bars with them. One of these standards was taken to Paris last year by Mr.

Fischer and recompared with the standards of the international bureau.

It will be remembered that in 1893 congress adopted the international meter as the fundamental unit of length, continuing the ratio of the yard to the meter as 36 to 39.37. At the same time the international kilogram was adopted as the fundamental unit of mass. Thus the old standard yard of 1840 and the troy pound of the mint of 1827 were superseded, and hence all measures of length and mass in either metric or English system are now referred to the international meter and kilogram.

We are at present prepared to determine the length of any standard from 1 decimeter to 50 meters, and also to calibrate the subdivisions of such standards and to determine the coefficient of expansion of the same for ordinary ranges of temperature. The bureau is also prepared at the present time to compare base-measuring apparatus and steel tapes, but the facilities are such that the best results are only attained at the expense of great labor.

The tunnel connecting the physical and mechanical laboratories will be fitted out with facilities for comparing this kind of apparatus. This tunnel will be 170 feet long, 7 feet wide and 8 feet high, and facilities will be provided for comparing tapes up to 50 meters in length and to lay out a base of the same length with an error not greater than one part in two or three million, over which base-measuring apparatus may be tested. Means will also be provided for raising the temperature to, say, 40° Centigrade, and lowering to 10° C., for the determination of temperature coefficients of apparatus submitted.

The bureau possesses two iridio-platinum copies of the international kilogram and also the necessary working standards to verify masses from 0.1 milligram to 20 kilograms. The balances now on hand include a series of the best American makes and one precision balance similar to those found at the International Bureau of Weights and Measures. These are to be supplemented by other precision balances now being constructed, and when the physical building is completed and the balances installed the determination of masses within the above-named range may be made with the highest degree of accuracy.

The determination of the density of solids and of liquids is also part of the work of this section. Two sets of Jena glass hydrometers, graduated to read densities directly from 0.6 to 2.0, and verified at the Normal-Aichungs Kommission of Berlin, form part of the newer apparatus of this section.

Capacity measures from 1 milliliter to 40 liters are being standardized, and plans are being made to test various kinds of chemical measuring apparatus in large quantities.

Aneroid barometers are also tested by this section, employing the very convenient apparatus designed by Dr. Hebe of the Reichsanstalt and used at that institution.

The bureau has also been called upon to advise the officers of state and city sealers of weights and measures regarding the proper equipment of those officers and the methods to be pursued in performing their functions.

SECTION 2. *Thermometry and Pyrometry.*—Facilities have now been provided for the testing of mercurial thermometers in the interval $-30°$ C. to $+550°$ C. The testing of toluene, petroleum-ether and pentane thermometers, and copper constantan thermocouples for low temperature work, will be undertaken in the near future, the range extending down to about $-200°$ C.

The standard scale of temperature adopted by this bureau for work in the interval $-30°$ to $+100°$ C. is the scale of the hydrogen gas thermometer, as defined

by the resolutions of the committee of the International Bureau of Weights and Measures, dated October 15, 1887. (This scale has now come into world-wide use, and its general adoption in all important scientific and technical work has contributed toward the solution of important questions bearing on the mechanical equivalent of heat and the international electrical units.)

As primary standards the bureau now has fifteen Tonnelot and Baudin thermometers that have been carefully studied at the international bureau and which are now undergoing further intercomparison here.

As primary standards, in the interval 100° to 600° C., Dr. Waidner has had constructed some specially designed platinum resistance thermometers, both of the compensated and potential lead type, together with resistance bridges and other apparatus designed to afford the highest accuracy and convenience in working. He has chosen the platinum resistance thermometer as the primary standard of the bureau because it defines a scale of temperature that is at any time reproducible in any part of the world, and unlike most standard scales, it is not locked up in a few instruments that have been directly compared with the gas thermometer. As secondary and working standards in this interval, 100° C. to 550° C., the bureau has a number of mercury thermometers constructed of French hard glass and of Jena borosilicate (59‴) glass. Those intended for work above 300° C. have the space above the mercury filled with dry N or CO_2 gas under pressure. These mercurial standards are intercompared from time to time and occasionally they will be compared with the platinum resistance thermometers.

In the interval 0° C. to — 200° C. the standard scale of temperature is again that of the hydrogen-gas thermometer, and here also the platinum resistance thermometer serves to define the scale. For work in this range the resistance thermometer is, as before, referred to three known temperatures, viz., melting ice, melting CO_2, and the boiling point of liquid oxygen. As secondary and working standards in this interval, the bureau has a number of toluene thermometers, and copper-constantan thermocouples; and, in addition, some petroleum-ether and pentane thermometers, for use as low as — 180° C.

The scope of the testing work in this field, which is rapidly increasing, is already somewhat varied. It includes the certification of precision thermometers to be used in scientific work, the certification of standards used by some American thermometer makers, of thermometers used in important engineering tests, and of special types of mechanical thermometers used in industrial operations.

One branch of testing which promises to grow rapidly is the testing of clinical thermometers. Special apparatus has, therefore, been designed and constructed in the instrument shop of the bureau, to enable this work to be carried on with the greatest rapidity and precision. As an illustration of the results attained, it may be noted that 600 clinical thermometers can be read, at one temperature, in the space of 30 minutes.

Special facilities have been provided for high temperature testing, such as the standardization and testing of nearly all kinds of high temperature measuring instruments, including thermocouples, platinum resistance thermometers, expansion and optical pyrometers; the determination of the melting points of metals and alloys; the determination of the specific heats and coefficients of expansion at high temperature, etc.

Some of the apparatus has already been installed for the determination of the calorific value of fuels.

For carrying on this work the laboratory has been equipped with gas blast furnaces; electric furnaces which will maintain for hours temperatures as high as 1,400° or 1,500° C., constant to within a few degrees; electrically heated black bodies; and the necessary accessory apparatus, such as potentiometers, special resistance bridges, recording pyrometers, etc.

As primary standards for work in the interval 600° C. to 1,600° C., thermocouples obtained from various sources are used. These couples are referred to the scale of the nitrogen gas thermometer by measurement of their electromotive force at known temperatures, viz., the melting or freezing points of some of the metals.

The high temperature scale used by this bureau is based on the melting and freezing points of the metals as determined by Holborn and Day in their painstaking researches on the nitrogen gas thermometer. The scale is thus a reproduction of the high temperature scale used by the Physikalisch-Technische Reichsanstalt, and its adoption serves to extend the use of a uniform scale, which is always to be desired in physical measurements.

The establishment of our standard scales and the development of the apparatus required in testing have necessarily taken the greater part of the time since the establishment of the bureau. Research work has not, however, been neglected. The establishment of the standard scales has opened up a number of problems bearing on heat and temperature measurements, the investigation of which Dr. Waidner and Dr. Burgess have undertaken; this will form an important division of the work.

SECTION 3. *Light and Optical Instruments.*—The work of this section, which is under the personal charge of the director, has only recently been inaugurated, and it can not be fully developed until the second of the new buildings is occupied. Dr. Nutting is now carrying on some investigations on the electrical discharges in gases, to determine among other things the conditions necessary for producing a given spectrum by such a light source. Mr. Bates is making a careful study of polariscopic measurements, with special reference to the accurate determination of the percentage of pure sugar in a sample. The bureau has undertaken, at the request of the Treasury Department, to supervise the work of polariscopic analysis of sugar in all the custom houses of the country, and this is being done by Professor Noyes and Mr. Bates.

SECTION 4. *Engineering Instruments.*—The work to be undertaken in the near future in this section will include the testing of gas meters, water meters and pressure gauges, and testing the strength of materials, using for the latter work a 100,000-pound testing machine. Preparations for this work have only recently been begun, but the work is progressing rapidly. The range of the work will be extended beyond that indicated above as fast as possible.

DIVISION II.

Section 1. *Resistance and Electromotive Force.*—This work was begun by Dr. Wolff in the office of standard weights and measures several years before the Bureau of Standards was established. It was, therefore, the first section of the electrical work to do testing for the public and is now in a comparatively forward state of development. In addition to standard resistances and standard cells this laboratory also tests precision resistance boxes, Wheatstone bridges, potentiometers, precision shunts, etc. Specific resistances, temperature coefficients and thermo-electric properties of materials are also determined. A considerable part of the work of this section consists in the verification of apparatus of this kind for the other sections of the bureau.

For the present all resistance measurements of the bureau are referred to the mean of a number of one-ohm manganin standards which are reverified from time to time at the Physikalisch-Technische Reichsanstalt, and are, therefore, known in terms of the primary mercurial standards of that institution.

The construction of secondary mercurial standards, which after suitable aging change less than wire standards, has been begun and in time will be of service in fixing with the greatest possible accuracy the value of the one-ohm working standards. It is intended as soon as possible to construct a number of primary mercurial resistance standards. A supply of suitable Jena glass tubing has been secured, but the urgent demands upon the section for testing and the limited force available preclude this important piece of work for the present.

The set of manganin resistance standards of the bureau consists of ten one-ohm coils and four coils each of the following denominations: 10, 100, 1,000, 10,000, 100,000; .1, .01, .001, .0001, .00001, besides two two-ohm, three three-ohm, two five-ohm coils and two megohm boxes, this giving in most cases two reference standards and two working standards of each denomination.

Special efforts have been made to secure the accurate comparisons of the one-ohm coils with those of the other denominations, bearing the ratios of 1, 10, 100, etc. For this purpose as well as for the most accurate measurement of other resistances, Dr. Wolff designed and had constructed by Otto Wolff, of Berlin, a special mercury contact Wheatstone bridge of the Anthony form. For directly determining the ratio of two nearly equal coils Dr. Wolff had a special set of ratio coils and a four-dial shunt box constructed which enabled the ratio to be read off directly to parts in a million, the dials reading respectively .1 per cent., .01 per cent., .001 per cent. and .0001 per cent. Other special apparatus has been built or is under way for making precision measurements with a minimum of labor in the observations and computations.

The legal standard of electromotive force in the United States is the Clark cell, the value of which is 1.434 international volts at 15° C. and is, of course, the value used by the bureau. The Reichsanstalt uses a value nearly 0.1 per cent. smaller, namely, 1.4328. This unfortunate discrepancy can only be removed by further action of the next international congress followed by an act of congress if a change is authorized, fixing anew our legal standard. The value 1.433 is, perhaps, the nearest value that can be assigned from present data.

A considerable amount of testing has already been done by this section, chiefly resistance standards and resistance boxes, but including also a variety of other apparatus.

SECTION 2. *Magnetism and Absolute Measurement of Current.*—Preparations are under way for magnetic testing, but want of laboratory space has retarded the development of this work. Dr. Guthe is carrying on two important researches, namely, a study of the silver voltameter and a redetermination of the electrochemical equivalent of silver and of the absolute value of the Weston and Clark standard cells. A new absolute electrodynamometer is to be built for the latter investigation. The results of the investigation of the various forms of silver voltameters have recently been communicated to the American Physical Society. The magnetic laboratory is about to be established, and magnetic testing and research will be developed as rapidly as our limited force will permit.

SECTION 3. *Inductance and Capacity.*—A careful study of mica and paper con-

densers has been made, including the measurement of their capacities by different methods, the effect of time of charge upon their measured capacity, and the determination of absorption, leakage and temperature coefficients. Condensers have been purchased from various makers in England, France, Germany and America, and comparisons made with a view of determining the best performance to be obtained from both mica and paper condensers when used as measures of capacity. Some very interesting and valuable results have thus been obtained, although the work is not yet completed. Two large air condensers have recently been constructed to be used as standards. A new form of rotating commutator for use in determining capacities in absolute measure has recently been completed in our instrument shop and has been used in this work.

A considerable number of standards of inductance have been acquired and a great deal of work has been done in comparing inductances and determining their values absolutely. The bureau is now in a position to make accurate measures of both capacity and inductance and to compare and test condensers and inductance standards for the public.

SECTION 4. *Electrical Measuring Instruments.*—This section includes both alternating and direct current instruments (including instruments for measuring heavy current and high potential) except those precision instruments included in Section 1. Some testing of ammeters, voltmeters, wattmeters and watthour meters has been done for the public, but the principal work done so far has been preparatory. Many instruments have been purchased from the best instrument-makers at home and abroad, and other instruments have been designed and built in our own shop. Much of the apparatus purchased has been tested and in some cases altered and improved. Methods of measurement have been investigated, and a considerable experience acquired preparatory to the equipment of the laboratory for this work in the new building, to which this work has recently been transferred.

In addition to direct-current generators and storage batteries the following equipment of generators for alternating current has been acquired:

1. A small 120-cycle alternator, single-phase, suitable for voltmeter or condenser testing.

2. A three-phase 120-cycle alternator driven by an inverted rotary used as a motor and itself capable of giving a three-phase 60-cycle current.

3. A pair of 60-cycle three-phase revolving field alternators (direct-connected to a driving motor), of which one can have its armature rotated by a hand wheel while running, so that its current is displaced in one phase with respect to the other. Using one of these generators for the main current (which by use of transformers may be multiplied at reduced voltage) and the other for the potential current, any desired power factor may be obtained and wattmeters and watthour meters conveniently tested up to a capacity of 1,000 amperes and any desired voltage.

4. A pair of two-phase alternators, surface-wound and giving currents of nearly sine wave form (direct-connected to a driving motor), one alternator giving 60 cycles and the other 180, arranged so that the two armatures may be placed in series and the wave form varied through a considerable range by varying the magnitude and phase of the third harmonic. This is useful in studying the effects of varying wave form on the indications of measuring instruments of different kinds. For studying the effects of variations of frequency the speed can be varied through wide limits, and, for higher frequencies, the

higher frequency machine may be used alone. Transformers are arranged to change these two-phase currents to three-phase when desired.

5. Another three-machine set is under construction by the General Electric Co. This contains two 60-cycle three-phase alternators, with adjustable phase relation and surface windings, giving nearly sine wave form.

Special attention has been given to the matter of accurately measuring frequency, phase and wave form as well as alternating voltages, currents and power. These latter quantities are measured by means of instruments which admit of accurate calibration with direct currents and electromotive forces, the latter being measured by potentiometers, using standard resistances and Weston cells, the e.m.f. of the latter being of course known in terms of the standard Clark cells of the bureau. Thus all current, voltage and power measurements, both direct and alternating, are referred to standard resistances and standard cells.

The alternating instruments employed are as free as possible from errors due to inductance, eddy currents and capacity. Corrections are applied for the effects of small residual inductances when necessary. The alternating generators employed are driven by motors operated from storage batteries, enabling the speed and voltage to be maintained very uniform and measurements to be made with great precision. Thus frequency, voltage, power factor and wave form are controlled and varied as desired, and every effort is made to secure accurate measurements.

The bureau is now prepared to test alternating voltmeters, ammeters or dynamometers, wattmeters, watthour meters, phase and power factor meters, frequency indicators and other similar apparatus. Recently some very careful tests have been made on a lot of watthour meters to determine separately the effects of varying the voltage, frequency, power factor, temperature and wave form from the normal conditions, and of the load from 1 per cent. to 150 per cent. of normal full load, and curves plotted showing these several effects. As some of these effects were small, and as only one variable was altered at a time, very accurate measurements were required to determine the effects in question.

In the testing of direct-current instruments the bureau is now prepared to handle apparatus of capacities up to 1,000 amperes and 1,000 volts. A larger storage battery is being installed, which will give currents up to 5,000 amperes at 4 volts or 10,000 amperes at 2 volts, and a high potential battery of several thousand volts will be installed in the near future.

Section 5. *Photometry.*—One of the rooms of the temporary laboratory of the bureau was early assigned to photometric work, and an equipment of apparatus provided for measuring mean horizontal candle-power of incandescent lamps. The work was inaugurated by Dr. Wolff, but is now in charge of Mr. Hyde. As soon as the new buildings are occupied this equipment will be greatly augmented and the work enlarged. After doing considerable preliminary work the bureau is now prepared to test and certify incandescent lamps to be used as standards, and has already done this in a number of cases for manufacturers and others.

The Hefner amyl-acetate lamp has been somewhat generally accepted as a primary photometric standard, but its numerous defects make it quite unfit for a working standard. After taking the most elaborate precautions to maintain a steady and uniform flame, and applying corrections for the pressure and humidity of the air and its carbon dioxide content, the best results of the most skillful observers differ many

times more than in the comparisons of incandescent lamps of approximately equal efficiency with one another. Moreover, incandescent lamps suitably prepared and properly used are very permanent, and, being cheap and portable, may be duplicated and frequently tested. By keeping one set of lamps as reference standards and another as working standards, and burning them at relatively low temperatures (that is, at about four watts per candle) there is good reason for believing that the average value of a set of standards may be continued indefinitely.

A considerable number of electric standards have been obtained from the Reichsanstalt, the ratio of the candle to the Hefner unit being taken as 1 to .88. These reference standards are, of course, only occasionally used, and the mean of the value of several 16-candle power lamps is taken as the standard of the bureau. Exact copies of these will be added from time to time, so that of a change in any lamp is detected it may be discarded without impairing the completeness of the set. The current and voltage employed in testing lamps are measured by a potentiometer, and can be maintained constant to the hundredth of one per cent. Working by the substitution method, it is possible to make very accurate comparisons and thus to secure very exact copies of the standards of the bureau. The bureau recently requested a large number of lamp manufacturers to send each two or three carefully rated 16-candle power lamps for comparison with our standards. The lamps submitted varied from 15.4 to 17.6 candle power, averaging 16.48 cp., or about three per cent. high. Several of the large manufacturers were quite near to our standard, and it appears from these results that if all lamp manufacturers were to adopt the standards of the bureau there would be very little change in the average candle power of all the lamps manufactured, although some would be raised and others lowered. Since uniformity is extremely desirable and is now more easily attainable than heretofore, it is to be hoped that this result will speedily follow. The close agreement between the standards of the bureau and those of some of the manufacturers is due to the fact that the latter are using incandescent lamps rated at the Reichsanstalt. For the same reason, standards of the bureau are also in close agreement with those of the Lamp Testing Bureau of New York.

The purpose of the bureau is not to undertake, at least for the present, the commercial testing of incandescent lamps, but (apart from the testing done for the government) only to verify lamps to be used as standards and to make special investigations of lamps submitted for the purpose. To this end no effort will be spared to maintain reliable standards and to certify copies with the highest possible precision.

DIVISION III.

As already stated, the chemical division was late in being inaugurated. Aside from the immense assistance which a chemical laboratory can render to physical investigations, the division of chemistry will have important functions in its relations to the chemical interests of the country, and to the customs service and other departments of the government. Some chemical work is now being carried on, and detailed plans are being developed for the chemical laboratory to be installed in the larger of the two buildings now under construction.

THE EXPOSITION LABORATORY.

In addition to the exhibit which the bureau is making in the government building at St. Louis, it has undertaken, at the request of the authorities of the exposition, to install and operate an electrical testing laboratory in the electricity building dur-

ing the exposition. The work to be done will include the verification of measuring instruments to be used by the jury of awards in testing electrical machinery, and the testing for the jury of awards of instruments and apparatus submitted by exhibitors in competition. It is obvious that the intrinsic merits of a galvanometer, potentiometer, resistance standard, or other measuring instrument, can not be entirely determined by inspection, but only by rigorous test, and that a fully equipped testing laboratory can render important service to a jury of awards in the important and responsible duties which the latter is called upon to perform. A large exhibit of electrical instruments and machinery is expected from European manufacturers, more particularly from Germany, and without thoroughly testing the competing apparatus it would be impossible to distribute awards justly. It is proposed to publish the results of these tests so that they may be a permanent contribution to our knowledge of electrical instruments and machinery.

This laboratory is located along the east wall of the electricity building, south of the east entrance. The space assigned to it is nearly 200 feet long by 23 feet wide. A series of rooms have been constructed, all of which, except the office, are being equipped for laboratory purposes. A refrigerating machine having a capacity equivalent to the melting of ten tons of ice in twenty-four hours will be used in connection with the ventilating machinery and heat-regulating apparatus to control the temperature and humidity of the atmosphere in the laboratories. Piers and other substantial supports for apparatus have been installed and every effort is being made to provide the facilities and apparatus necessary to do precision testing.

In addition to doing the official testing for the jury of awards, testing for others will be done as far as practicable. For such work charges will be made according to the regular schedule of fees of the bureau. The laboratory will also serve as a working exhibit, and visitors will accordingly be admitted at certain specified times. For this reason, the exhibit of the bureau in the government building will be largely historical and educational and mainly devoted to subjects other than electricity.

EQUIPMENT OF THE BUREAU.

Some account of the proposed equipment of the new laboratories of the bureau has been published* in connection with the plans of the buildings, consequently no attempt will here be made to describe again either the buildings or their general equipment, or to go into detail regarding the equipment for any particular line of work. The intention of the bureau is to provide every facility necessary for experimental work, both for research and testing, and to have a sufficient force of engineers, firemen, electricians and other assistants so that the service may be available at any or all times. The instrument shop is already well established, and the expectation is to have it so well manned that any of the various sectional laboratories can be promptly served whenever the work of testing or research makes the services of a mechanician necessary. To do this will require a considerable increase over the present force. Indeed, it is likely to be several years before the personnel will be so far increased as to meet urgent requirements. Notwithstanding the considerable force of men now at work, the bureau is seriously in need of more clerks, mechanicians and laboratory assistants; besides research workers and men to inaugurate new work, who are also much needed.

It is needless to emphasize further the importance of the highest standards in all

* Science, January 23, 1903.

the work of the bureau. Every new line of work taken up means a new research, and often the designing and building of a new series of instruments. As the limits of errors are narrowed the labor is rapidly augmented. What one man might do well in a day may require two men a week or a month if the accuracy is to be considerably increased. This will explain why the bureau has not already announced a greater range of testing, and why even when both the new buildings are occupied many lines of work will remain to be inaugurated.

It is the constant purpose of the bureau to cooperate with instrument makers and manufacturers to the end that their output of instruments and apparatus may be improved. Not simply to certify errors or criticize results, but to assist in perfecting the product, is the aim. In this work the bureau has so far enjoyed the confidence and cooperation of manufacturers to a gratifying degree. It was largely to meet their needs that the bureau was organized, and if by serving them the standard of excellence of American-made instruments and machinery is raised, the bureau will have served the public also. In several specific instances a marked improvement of this kind is already seen, due directly to the influence of the bureau of standards.

The advantage to scientific men and engineers of having a place in this country where instruments and standards may be verified with the highest possible precision, and at nominal charges, and where researches may be undertaken when necessary to answer questions arising in such comparisons, is evident. It greatly facilitates precision work both in engineering and in research.

The bureau has also fulfilled another of the functions mentioned in the act authorizing its establishment, in furnishing information on a variety of subjects included more or less closely in its field of activities. A considerable correspondence of this kind has grown up.

The functions of the Bureau of Standards are very broad and its possibilities for usefulness correspondingly great. It should do in its field, indeed, what the Coast Survey and the Geological Survey and the Department of Agriculture are doing in theirs, and what the Physikalisch-Technische Reichsanstalt and the Normal-Aichungs Kommission are doing in Germany. Fully to realize these possibilities will of course require a much further increase in equipment and in personnel, and this we expect to see.

EDWARD B. ROSA.
NATIONAL BUREAU OF STANDARDS.

SCIENTIFIC BOOKS.

Christian Faith in an Age of Science. By WILLIAM NORTH RICE, Ph.D., LL.D., Professor of Geology in Wesleyan University. New York: A. C. Armstrong & Son. 1903. Pp. xi + 425.

As the author himself hints in his preface, it would not be difficult to cull some delightful antinomies from this work, and on a scale more extended than Dr. Rice suspects. At the same time, it was ever thus with books of the class. For example, I can picture the meaningful smile that would cross the faces of certain experts I could name, when they read those pronouncements: 'It is evident, in general, that we have in the book of Genesis nothing that approaches the character of reliable history till about the time of Abraham (p. 122); the Fourth Gospel is probably the only record by an eye-witness of the events connected with the resurrection' (p. 363). Similarly, in another field, when Dr. Rice suggests that the virgin birth and the resurrection—in the most usual acceptation of these terms—are essential to Christianity (p. 377), one is bound to refer him to the relative articles in 'The Encyclopædia Biblica.' In the same way, his naïve account of will would scarcely satisfy psychologists, while his fearfully and wonderfully made presentation of causality would amaze the thoroughly modern metaphysician.

But, even admitting these points, it would be a great mistake to dismiss the work thereupon. Its account of the progress of science, and of the resultant transformations wrought upon mediæval beliefs and whimsical suppositions, is very well done. Nay more, it marks a distinct advance over nearly all statements of the kind known to me. A few passages, culled at random, serve to prove this clearly: "The belief that the writers of the Bible were under the special influence and guidance of the Divine Spirit is a very different thing from the belief that their opinions were always just, their arguments always conclusive, or their knowledge of the facts always accurate" (p. 85). "We have come to regard as the main function of prophecy, not the construction of a map of all future history with symbols and names in cipher, but the presentation of warnings, consolations and moral exhortations, to reform or confirm the religious faith and life of the people addressed" (p. 106). "The conclusion which seems forced upon us is that no reconciliation between the geological record and that of Genesis is possible" (p. 111). "Apart from the dogma of the inerrancy of the Bible, the question of the date of the origin of man has obviously no theological significance whatsoever" (p. 117). "Wallace announced many years ago the remarkable proposition, that 'every species has come into existence coincident both in space and time with a preexisting closely allied species.' It would be impossible actually to prove that proposition in regard to every known species, since our knowledge of extinct life is so far from being complete. Nevertheless, the proposition can be shown to be true in so many instances that there is no reasonable doubt that it is to be accepted as a universal law. * * * The cumulative force of that evidence reveals itself only in prolonged study of some one or other of the departments of biology" (pp. 194–5, 198). "The theory of evolution is indeed the implacable foe of that sort of theistic philosophy which has been happily satirized in the phrase, 'the carpenter God'" (p. 254). "I can not escape the conviction that the tendency of evolutionary thought is decidedly towards monism" (p. 268). "It is difficult to see why that parallelism of ontogeny and phylogeny does not have the same significance in regard to psychical as in regard to physical characteristics" (p. 272). "The alternatives for the philosophical thinker seem to be dualism and monism, but with a third alternative of suspended judgment—agnosticism" (p. 275). "Neither volition nor any other mental state has a quantitative relation to physical energy. The recognition of the absolute disparateness of the two classes of phenomena is essential to sound thinking in regard to them" (p. 296). "The things which we can not predict we can pray for. The things which we can predict we can not pray for" (p. 346). "It is needless to say that no claim of certainty can be maintained in regard to Christianity as a system, or in regard to any particular doctrine of Christianity" (p. 406). All this is pretty well. These views, and others like them, are decidedly symptomatic.

Part I., which deals with science and its advance, will be of great service to many. Parts II. and III., which contain the philosophical, theological and religious considerations, can not be ranked in the same class. They are immensely weakened by absence of a transitive grasp upon first principles and, therefore, on the whole, they never really face the ultimate question, What are we *compelled* to infer to-day from man's knowledge of the physical universe, of the physiological body, and of the psychological organization? Yet, even at this, the book must be strongly commended to thousands who have hitherto been fed on mush, discreditable to its cooks and positively harmful to its consumers. For many babes Dr. Rice may prove strong meat, indeed. And from this point of view, his work deserves hearty recognition as a valuable installment, likely to carry advantageous weight in certain quarters.

R. M. W.

SOCIETIES AND ACADEMIES.

THE NEW YORK ACADEMY OF SCIENCES.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

The regular meeting of the section was held April 25 at the American Museum of Natural

History in conjunction with the American Ethnological Society. The program was as follows:

Notes on an Algonkin Dialect: Dr. WM. JONES.

Dr. Jones presented a brief report on the method of word-formation of the Fox dialect. The dialect is Algonkin and belongs to the group now inhabiting, or that once inhabited, the country contiguous to Lake Huron, Lake Michigan and Lake Superior. Among the other dialects of the group are Ojibway, Ottawa, Pottawatomi, Menomonie, Kickapoo and Sauk. Morphologically all these dialects stand in an intimate relation with one another. The absolute forms of much of the vocabulary are the same, but varying differences in the way of intonation, articulation and grammar make some of the dialects seem somewhat removed from one another. Fox is nearest to Sauk and Kickapoo and farther removed from Ojibway.

The structural peculiarities of word-building as shown in the Fox would come out much the same in the other related dialects. The system of forming words is by composition. The elements entering into composition are formatives and stems. Some formatives are prefixes but most are suffixes. Some of the suffixes refer to the pronoun and gender in the same form. Stems fall into two general classes, initial and secondary. Initial stems come first in a combination and secondary stems come after. Secondary stems can be subdivided into at least two groups, one of a first order and another of a second order; the former stand next to initial stems, and the latter, when in composition, stand next to terminal pronouns.

The stems refer to general notions. Initial stems usually express subjective states and secondary stems generally refer to objective relations. The meaning of one stem modifies the meaning of another in a reciprocal manner with the result of greater specialization. Initial stems have greater extension and can often occur alone as adverbs.

A number of particles precede the terminal pronouns. The particles refer to causal relations. Some have the special office of instrumentality, as with the hand, foot, mouth, voice and ear.

The dialect makes a distinction between two opposing categories. Objects that have life and movement come in one class and objects without those attributes fall in another. The distinction is maintained with great vigor throughout the dialect; a force like personification sometimes interferes with it.

On the Growth of Children: Professor FRANZ BOAS and Dr. CLARK WISSLER.

Professor Franz Boas and Dr. Clark Wissler presented a joint paper on the growth of children, in which they discussed the causes of the increased variability during the period of growth. As the results of previous investigations, it had been suggested that the increased variability may be due to differences in the rapidity of development. The authors have followed out this line of investigation by collecting material regarding the variability of the period at which certain physiological changes take place. The times of dentition, the beginning of puberty, the appearance of the wisdom teeth, and the beginning of senility were selected for this purpose, and it was shown that the variability of time at which these phenomena take place increases with increasing age, and apparently the rate of increase of the variability is proportional to the age. Furthermore, it was shown that during the period of growth all the coefficients of correlation between the sizes of different parts of the body are increased. This can also be best explained by the theory that the phenomena of growth are largely due to acceleration and retardation.

Paper-making Implements of Ancient Mexico (with demonstration of specimens): Professor MARSHALL H. SAVILLE.

The Grammar of the Yukaghir Language: Mr. WALDEMAR JOCHELSON.

The paper reported the result of several years' study of the Yukaghir language, being mainly a sketch of the Kolyma dialect. There are two dialects in the language,—the Tundra dialect, and the Kolyma dialect. The phonetic and morphological peculiarities of the former are rather insignificant, but the Tundra dia-

lect has absorbed a considerable number of Tungus stems, which in their use in word-formation have been subjected to the rules of the Yukaghir grammar. These investigations show that the Yukaghir language stands isolated from the Siberian languages of the so-called Ural-Altaic group, and that it has many similarities to the languages of the American Indians.

The chief phonetic and morphological differences that distinguish the Yukaghir language from Ural-Altaic languages are the following: (1) It has not the intricate system of vowel harmony that is found in Ural-Altaic languages; (2) we do not find that the vowel of the root is unchangeable—an important rule in Ural-Altaic phonetics; (3) the Ural-Altaic possessive suffixes of nouns and verbs are wholly absent in Yukaghir verbs, and present in nouns only for the purpose of expressing ownership of the third person; (4) words are formed by means of suffixes and prefixes, while the Ural-Altaic languages use suffixes only.

The chief points of similarity between the Yukaghir language and Indian languages are: (1) The existence of a simple harmonic law in the use of vowels; (2) the use of prefixes; (3) adjectives are morphologically identical with verbal forms; (4) the verb-bases are mostly stems consisting of a single vowel or a small group of consonants, while the noun-bases are almost always derivatives of verbal forms; (5) the conjugation of transitive verbs is clearly distinguished from that of intransitive verbs; (6) transitive verbs may be changed into intransitive verbs by means of suffixes, and *vice versa;* (7) we find in the Yukaghir language the 'polysynthesis' of the American languages; (8) although there is not the actual 'incorporation' of the American languages, the syntactical construction of the Yukaghir sentence is akin to it.

James E. Lough,
Secretary.

DISCUSSION AND CORRESPONDENCE.

A FLYING MACHINE IN THE ARMY.

To the Editor of Science: In recent numbers of various journals, much has aptly been said about flying machines, balloons, aeroplanes, kites, aerodromes and mechanical means for navigating the air, with historical data, giving credit where credit is due and naming several of the great thinkers of the age and what they have done in this direction, with hints for the future, but not a word of what the army has done seems to have been printed.

For ages commanders in the field have desired to know what the enemy was doing. Hence the use of captive balloons and the wish to make them dirigible; and when the Astronomer General Mitchell commanded at Port Royal during the civil war, the matter was discussed with his chief engineer officer, who brought forward the proposition to make a *machine* without inflation, and exhibited a tin model that wound up with a string and a handle and spun like a humming top and would fly into the air a hundred feet or more, vertically, according to the force exerted upon it, and would carry a bullet or two if the string was pulled hard enough. From this little toy which was a circular disc of tin, so cut and bent as to make a fan-screw wheel, it was argued that with power enough, if it could be had within the necessary limit of weight, such fan propellers could be made and combined as to lift an observer into the air and by other horizontal propellers could be driven through the air, and by making one on a horizontal shaft so that the direction of its axis could be changed at will, the machine could be steered.

That it must have power to be driven faster than the wind moves was apparent or the wind would take it as it does a balloon. At that time balloons were very simple. No one had made progress in directing their flight.

Mitchell was a mechanician as well as a mathematician, and was proud of being able to measure the one ten-thousandth of an inch accurately, and he concluded that it would be well to consider the problem of air navigation without gas bags. But the yellow fever claimed him, and for a long time no more was done in that direction at department headquarters.

The Tenth Army Corps had a captive balloon, but it was of little use, except to excite

the wish that we had something better, and during the siege of Charleston Major Richard Butt and Captain James E. Place, of the engineers, and myself frequently discussed the details of a machine that should not only take up observers and go where we wished and come back, but carry bombs with high explosives to punish the enemy. The 'come back' part was of importance. The balloon would go, if the wind was right, but we had no way to make it come back as was wanted, hence it was never made to *go*.

The flight of birds was observed, buzzards, crows, eagles and gulls particularly. The machine must meet the requirements, to start, to go, to come back, to land safely—all were considered. There was no record that these questions had ever been before considered to be done mechanically, without gas. We considered gas-bag inflation as so objectionable as to be out of the question. Any machine held up by rarefied air or its equivalent presented so large a surface that power could not be had to drive it against the air, and unless it could go against the air quicker than the air itself moved, it was of no use for our purposes.

The ordnance department had tables of atmospheric velocities, so it was known what had to be encountered. During the siege of Charleston nothing was accomplished, but shortly after the Tenth Army Corps was moved up into Virginia and Petersburg was attacked, the means of finding out what the enemy was doing became a very prominent question with the engineers.

The tin toy was experimented with and a four-inch diameter fan was spun up to an elevation of over a hundred feet.

Major-General Benjamin F. Butler commanded the Army of the James and that included the tenth corps, and upon seeing what the tin toy did, immediately expressed the belief that a machine could be made that would navigate the air and give us the information desired, and could do more by dropping high explosives, and gave the writer an order to report officially upon the subject. No data could be found that gave any encouragement. The Duke of Argyle had organized a society in England, of which he was president, but except with gasholders to sustain the weight his society had done nothing. This society was communicated with, but before any reply was received drawings were made for a machine that should be screwed up and screwed forward, which if it could be made to ascend could be made to descend as slowly as desired, and it was to have planes by which to glide.

The theory was to imitate the little tin model and add to it gliding planes, and the drawings showed four fans to lift, two above an engine, two below, and two fans to propel and steer, one in front and one behind; the rear fan on a shaft that moved in a horizontal segment, so as to change the direction of the push, and make the rear fan not only a propeller, but a rudder at the same time. Across the machine was to be a horizontal shaft, on which on either side of the machine were to be gliding planes and automatic balancing balls. These were to slide in and out so as to maintain an equilibrium.

It had been observed that buzzards secured a vast amount of their progress by gliding, and the intention was to screw up and then glide in a descending curve, and by so doing save power, using the weight of the machine itself, and when the curve had come near enough to the earth, change the angle of the gliding planes, and by momentum go up as far as the impulse would aid in doing, using again at the same time the elevating screws. It was provided with a light supporting frame like the runners of a sleigh, on which to alight and to stand when at rest.

The body was to contain fuel and water and a high-pressure boiler and engine, and was to be shaped like a thick cigar. The length of the machine was about fifty-two feet, and from tip to tip of the gliding plane wings a little more. It was proposed to hang from the middle of the body a weight that could be lifted or lowered to act like the legs of a bird in flight and to balance it as the tail of a kite does. This vertically hanging weight was also to extend or draw in the balancing balls after the manner of the balancing pole used by the tight-rope walker.

It was argued that as a locomotive made to

walk on four legs, imitating a horse, was not a success, while the round leg as a wheel, acting continuously, was all that was wanted, so too the lifting and propelling fans, being intended for continuous motion, should do the work of wings and, better than reciprocating mechanical appliances, made to flap, condense the air, lift the body, release and flap again.

General Butler was so impressed when he saw the drawing and heard the explanation, that he ordered the machine to be built at once, and put the work in my charge.

There was, however, no appropriation that could be used to pay for it, and it seemed that nothing could be done; there was a very good engineer park, but the tools and machines at disposal were not fine enough to cut gear or to bore cylinders. Fortunately some patriotic citizens, who should be forever remembered, generously offered to pay the bills. Mr. Frederick Prentice, Mr. Wedworth W. Clarke, of New York City, and Mr. Sully, who were among the pioneers in the petroleum fields and were growing rich very fast, said: 'Send the bills to us; we will pay for anything wanted and will help to get it.'

The first thing done was to make a fan eighteen inches in diameter, rotate it at different speeds and see how much it would lift. The fan was made of very thin brass, and upon a wire frame, very much the same shape as those now used for ventilating and blowing, driven by electricity. It was found that a hollow blade with a blunt shoulder seemed to be best.

It was found that very considerable weight could be lifted, and to try what could be done on a large scale, a fan about thirty-two feet in diameter was made, the blades of the thinnest sheet iron that could be procured, and rotation by belt was provided.

Contrary to expectation, when the fan was first rotated at great speed in a foundry that had a high roof, the weight that could be lifted was much more than the wheel itself, some six hundred pounds or more, and then within forty seconds of time the wheel and the weights would drop back to where they started from, it mattered not how fast the fan was driven.

This was a puzzle, indeed. Why did it act so? When spun at a given speed, starting from at rest in still air, a certain velocity would make the wheel jump up the vertical shaft very quickly, lifting its own weight, and then suddenly, and as the velocity was increased, it would, after an interval never longer than forty seconds, slide down the vertical shaft, not sustaining its own weight. Hundreds saw it. The test was repeated again and again. No one understood why it did as it did.

Resort was then had again to the eighteen-inch brass wheel and it was found that after a certain period it went through the same manœuvers as the large fan, but the period of ability to lift was many times longer in the small than in the large.

It was found after a long investigation that the fan wheel of any size, when rotated in one place, set up a downward current of air that soon became nearly or quite as fast as the pitch of the fan, hence it would lift nothing. When, however, the fan was mounted at the outer end of a long boom, which revolved around a mast, so as to constantly bring the fan into new air, its lifting capacity never deserted it and bore a certain ratio to the velocity, and data were accumulated for proportioning the machine.

In those days there were no such machines as are now to be found everywhere, by which the horse power required at different velocities could readily be accurately measured, and some difficulty was experienced in approximating the requirements.

The questions involved seemed to be the size of the fan, the shape of the blade, the power required, the weight of the engine, boiler, fuel and water to develop the power.

Major-General Quincy A. Gillmore was an engineer officer of very high reputation and of considerable learning. He was asked to examine the plans and the data that had at this stage of the investigation been collected. He certified as a matter of opinion that it was 'all right.'

There were no dynamos or storage batteries, liquid air engines or sources of powerful energy using light-weight machines, and the only

prime motor sufficiently reliable was the steam-engine.

To get the strongest and the lightest was the problem.

It is true that carbonic acid had been liquefied some years before then, but no one knew how to harness it.

Having determined the probable force wanted, engine builders were found who agreed to make the engine light enough and of sufficient horse power, and the frame of the machine was set up at Hoboken, N. J. The fans were made for the lifting and driving, and the intermediate gear of bronze was cut. The body of the machine was complete.

At this stage it seemed that it only remained to get pressure enough upon the piston of the engine and maintain that pressure.

During the siege of Fort Wagner before Charleston we had used calcium lights, and had had great trouble to make the gas holders tight enough to prevent leak at high pressures. Mr. Mirriam, of Springfield, Mass., had succeeded in the field by a new method of floating the joints. Bennett and Risley, of Greenwich Street, New York, who undertook the engine, believed that they could make the joints of the boiler, the gaskets, the grummits and moving parts of the engine so as to work well under the required very high pressure of steam, by their new process, which seemed reasonable. Weeks, however, ran into months. They were unfortunate in their experiments, and the needed force of steam was not reached before the coming of Appomattox.

A description of the machine with a general and some detail drawings with tabulated data of the lifting capacity of the fans was filed with a rough model in the engineer department of the army at Washington, D. C., and a copy of the general plan was given to Mr. Prentice, whose office is now at 44 Broadway, New York City, and the Duke of Argyle was informed of what had in a general way been done by the army.

My conclusion was that at that time no existing machine would develop power enough to fly mechanically, without the use of gas-holders.

The use of liquid carbonic acid gas, CO_2, has changed the situation. Valves have been made to work well at great speed under three or four times the highest pressure of steam applied to reciprocating engines, and about five years ago a report was so made to the chief of engineers of the army.

The elimination of the boiler, water and fuel and the substitution of stored energy in the shape of liquid CO_2 greatly reduces the weight of machinery, and the conclusion reached at the last analysis of this problem is that for army use a radius of action of about eight hundred miles is now attainable, after some experimentation, as the chief difficulty, the valves, have already been tested to a success with pressures as high as are necessary.

Nothing is known by the writer of the details of the machinery recently tried by the brothers Wright in North Carolina, except that obtained from imperfect newspaper accounts, but from what has been published it would seem that their machine is very much like, if not identical, with the army machine here described; but whether this is so or not, they are to be most heartily congratulated upon the measure of success that has crowned their efforts, and this kind thought extends to my friend of years gone by—Chanute—who is reported to have helped them.

EDWARD WELLMAN SERRELL.

WEST NEW BRIGHTON,
STATEN ISLAND, N. Y.

NOTES ON ANIMAL BEHAVIOR.

TO THE EDITOR OF SCIENCE: It has been suggested to me that it would be worth while to put on record two or three rather curious instances of animal behavior which have come to my notice during the past few weeks. The subject of these observations is a two-year-old black-and-tan terrier belonging to my sister. A few weeks ago as the family was at dinner one evening my mother said, 'What did the postman bring this afternoon?' 'Only a couple of advertising cards,' said my sister, 'which I threw in the waste-basket.' Nothing more was said on the subject, but a moment later the dog, who had been sitting on a chair in the same room, ran to the basket and, taking one of the very cards referred to in his mouth,

ran around the table and stood with it beside my mother, looking up into her face and wagging his tail. I fear that some of our popular writers on animals would at once attribute a rather remarkable reasoning power to this dog, saying that he thought my mother would like to see the card, and so selecting it from the others in the basket took it to her and expected to be rewarded for his thoughtfulness. But there is a much more reasonable explanation. He is still very playful, and as he jumped from the chair and ran about the room the card projecting above the edge of the basket caught his eye, and the play instinct prompted him to seize it. The fact that he did this just after my sister had spoken of the card was a mere coincidence. His running to my mother with the card is easily explained. Several months ago, while he was still a puppy, in fact, he frequently pulled papers from this same basket and was punished for doing so, until he entirely gave up the habit. As soon as he had taken the card from the basket, the memory of former punishments for similar acts doubtless recurred to him. Now my mother is intensely sympathetic, and whenever he is punished or likely to be punished he invariably runs to her, knowing that he will be petted and may even get a lump of sugar; if the recollection of punishment came to him, he would naturally follow his habit and run to her.

It was about a week after this that my sister sat in the same dining room later in the evening reading a book, while the dog, who is as restless as dogs of that variety usually are, was running about looking for something to play with. At last my sister said, without looking up from her book and in an ordinary tone: 'Teddy, if you go down cellar and bring up a stick of wood, I'll play with you.' The dog stood beside her as she spoke and immediately darted out into the kitchen, down the stairs into the cellar and soon reappeared beside my sister with a stick of wood. This was not a trick that he had been taught. He has several times during the past winter carried sticks of wood from the cellar to the kitchen, and at times has been praised with such words as: 'Nice dog to bring up wood from the cellar.' But this carrying the wood has always been done voluntarily. Different members of the household when in the cellar have told him to carry up sticks, and he has never done so; sometimes a stick has been put in his mouth in the cellar, but after taking it as far as the stairs he would drop it and run up alone. He has been told a few times to go to the cellar and bring up a stick, but no attempt has been made to teach him to do so, and he has never done it except in the instance noted above. Since the evening in question the same remark has been made to him several times, and he has not responded to it in any way. The explanation would seem to be that he had learned to associate the words 'cellar' and 'stick' with the objects themselves and probably the word 'play' with the corresponding activity, for my sister plays with him a great deal and on such occasions frequently repeats the word 'play,' as 'Now let us play' or 'Come, play with your ball.' At the time in question the play instinct acted as a strong stimulus, probably a 'felt-need' from within, such as I have referred to in my text-book, and hence the special response. The whole act, then, involves no factors more complicated than memory and the association of names with objects, a faculty which dogs possess in considerable degree.

This same terrier, for example, associates the word 'ball' with the corresponding object with which he plays. If some one is in the pantry and you say to him, 'Go to the pantry and they will give you a piece of dog-biscuit,' he invariably goes for it, as he has doubtless learned to associate the words 'biscuit' and 'pantry' with the objects themselves. In the same way if you say to him, 'The grocer is coming into the kitchen to take orders; you must stay here in the dining room,' he invariably does so, although he is always very eager to see and jump upon any person who enters the house. The simple words, 'Grocer! stay here!' will have the same effect in keeping him out of the kitchen. He has likewise learned to associate the words, 'He is coming,' with the approach of any one to the house. I generally go home only on Sundays and at variable hours, and if the house is

quiet my mother sitting in the drawing room can say quite softly, 'I believe he is coming,' when the dog, two or three rooms distant and apparently asleep, will start up and run from window to window, looking up and down the street. He will do the same on any other day and for any individual, but with some variation in the rapidity of his response. I record these acts merely to show that while they might superficially appear to be the result of reasoning processes, they are doubtless only instances of memory and the association of spoken words with the objects or acts.

ARTHUR W. WEYSSE.
BOSTON, MASSACHUSETTS.

SPECIAL ARTICLES.

THE INHERITANCE OF SONG IN PASSERINE BIRDS.

REMARKS ON THE DEVELOPMENT OF SONG IN THE ROSE-BREASTED GROSBEAK, ZAMELODIA LUDOVICIANA (LINNÆUS), AND THE MEADOW-LARK, STURNELLA MAGNA (LINNÆUS).

I AM tempted to elaborate at some length the life history of two broods of young birds that were raised in May and June, 1903, that definite data may be before the reader and student, as to exactly what has occurred for the past year with the individuals under observation.

On the 7th of June, 1903, I found a nest of rose-breasted grosbeaks in a swamp on the Millstone River, near Princeton. At the time of discovery the female was sitting, and presumably brooding new-laid eggs. She was not disturbed, but as I did not know when incubation had commenced, the locality was visited and observations were made at intervals of every other day, until on the 14th of the month I was assured that the young had been hatched. I was not then aware of the number of fledglings composing the brood. It seems worthy of record here that both parents took part in incubation, though the male only assumed such duty for brief periods, when the hen bird went away, probably for exercise and bathing, but not in quest of food. The male constantly fed the female and was solicitous in his care for her.

On the 14th of the month the young were hatched, and the parents shared the duties of brooding as they had shared the period of incubation. On the 19th of the month, concluding that the young were old enough for the experiment in view, I secured the nest, in which were a brood of three fledglings, and at once had a water-color sketch made of the young in the nest, as a record of their absolute condition, so far as feathering and appearance were concerned. While not able to discriminate with certainty the differentiation in sex, I was reasonably sure from the first that the brood contained two young male birds and one female.

On the 20th another accurate water-color sketch was made to record how these birds had grown and developed, and on the 21st a sketch of one of the birds, a male, for by this time the sexes were easily distinguishable, records his appearance from both a front and a back view.

These birds were carefully hand reared in the nest, which they left on the twenty-first inst., when about seven days old. Grosbeaks of this kind are very precocious, and being admirable climbers, they clamber about long before they are able to fly, on the limbs and tangle of vines which generally surround the nest.

It seems improbable that during the first four days of their lives these birds acquired much appreciation of the song of the male parent, though he was constantly singing close at hand.

The three young birds were successfully reared, and are alive at the present writing. The brood consisted, as I had anticipated from the first, of two males and one female. The birds were kept together for the first six or seven months of their lives, in a large cage, and as I had no other male grosbeak in my laboratory, it was, of course, quite impossible that they should have learned anything of the method of song of their ancestors, except such impression as may have been gathered during the first four days of their lives. All of them went through the regular moult, and assumed by September the characteristic dress of rose-breasted grosbeaks at that season of the year. In October the two young males both developed a change in appearance which progressed slowly

until near Christmas-time, when they began to appear like adult male grosbeaks in full spring plumage. I was not a little chagrined that during September and October they showed a disposition to quarrel and harass one another, so that many of the feathers of the tail were broken and ragged, and the birds presented a rather worn and torn plumage. My experience has been that with most passerine birds, the primary quills and the feathers of the tail are retained for the entire first year without change. I had, however, discovered that young Baltimore orioles moulted the rectrices during the months of January and February, and was, therefore, prepared for a similar moult in these grosbeaks, for I find that in very highly colored birds, while the primaries are not moulted during the first year, but attain their brilliancy either by wear or *by direct change in the color of the feather,* the tail feathers of such birds, at least in a number of species, are moulted. Any one who is familiar with the color pattern of the rectrices of adult Baltimore orioles and rose-breasted grosbeaks must be aware that there is a very strongly contrasted area of either black and yellow or black and white on most of the feathers. To emphasize the matter let me say again that Baltimore orioles and rose-breasted grosbeaks both moult their entire set of tail feathers during January and February, and acquire by this moult the distinctive color pattern which is characteristic of the adult bird.

In the case of my grosbeaks, with this moult of the rectrices they recovered rapidly their fine appearance, and are indistinguishable at the time I am writing from wild representatives of their kind out of doors. Therefore, my apprehension that they might not present a fine appearance was unwarranted, for the reason that I have fully explained.

With the primaries the change seems to be effected, so far as I have observed, in a different way, which I ascribe, as I have said before, partly to wear of the surface of each feather, but, besides this, *I am strongly inclined to the opinion that there is a physical change in the feather itself, which alters its appearance so far as color is concerned.*

The moult was about completed by the 10th of February, but previous to that time I had detected a slight motion of the throat and body, indicating that the two males were beginning to sing. At first it was hardly possible to detect anything but the faintest sounds, but in a week or ten days I could discriminate the song, which I shall describe as nearly as is possible, in words. The tone, on the whole, is extremely musical, and has the soft plaintive quality characteristic of the rose-breasted grosbeak. It is very melodious, and while the birds have continued to sing daily to the time of this writing, no one would refer the *method* of song to the bird in question. While it is fully as prolonged as the song of the rose-breasted grosbeak, as we know the bird out of doors, it has not nearly the volume, and is not so abruptly broken. The notes are low and flute-like and resemble strongly the kind of song one associates with robins and thrushes in the autumn or late summer for a short period, after they have completed the moult. I have had a number of competent observers listen to the performances of these birds on many occasions, and all agree with me that the song could not be referred to the rose-breasted grosbeak. It is true and entirely possible that later the birds may develop a more characteristic song, but inasmuch as the time approaches when wild rose-breasted grosbeaks make their advent in this vicinity, coming from their winter homes, I am inclined to believe that these birds have now acquired the song that will characterize them throughout the period of breeding. I may say that I have mated two of the birds, one of the young males and the female, and have secured an older female from another source, with which I have mated the other male bird. I trust that I may be able to report, later, successful efforts in breeding these birds in captivity, and further data concerning the method of song which may obtain amongst them. This finishes my remarks in regard to the rose-breasted grosbeaks, and I now propose to give some data in regard to meadowlarks, obtained about May 25, 1903.

I shall speak of the meadowlarks in a much more general way than of the grosbeaks, as

I have been unable to watch them as closely, for they have not been caged, but have been at large, first in a room by themselves until February, and later associated in another room with a number of meadowlarks that had been reared in previous years. I particularly wish to refer to one of the birds, a male which has arrested the attention of all observers.

In the same room with these larks there are three blackbirds, *Merula merula* (Linnæus), which I procured from Germany. All of these birds are males, and they sing chiefly late in the afternoon, but much more frequently during the night, especially when there is moonlight. Early in February I heard constantly what I supposed was the song of one of these blackbirds. The curious part of it was that only one measure of the song was produced, a silvery whistling sequence of five or six notes rather longer drawn out, and given with much precision. For several weeks I ascribed this to one of the blackbirds, and believed that because of the shelter afforded them by many evergreen trees in my bird room that it could only be this bird, though I was unable to see the singer while hearing the song. My friend, Mr. Horsfall, who was with me during all the time, checked my observations, but we neither of us were able to *locate* the songster.

One of my meadowlarks of the brood mentioned attracted our attenion by his behavior and deportment during the early part of April. In addition to his song, which was quite dissimilar to that of a wild meadowlark, he accompanied the performance by what I should call a parade or dance, analogous to the strut of the turkey-cock. It is so marked a characteristic of this and other individuals of the same species that I determined to have it recorded in a color sketch, and for two or three days Mr. Horsfall and I spent much time in getting the position and manner of the bird while occupied in this kind of behavior. The bird sang frequently while going through the manœuvre described, and both of us finally saw and heard him many times sing, preparatory to or after his own song, the cadence described, which I had referred, before I saw the meadowlark do it, to the European blackbird.

While I am fully aware that under the artificial conditions of confinement birds are extremely likely to acquire abnormal songs, I can not but feel that the knowledge of the methods of song which has come to me while watching birds under these conditions, indicate a receptivity which to some extent undoubtedly obtains in their lives out of doors. My conclusion is that birds are influenced in their early lives very strongly by any noise that arrests their attention, even in a wild state, and that this propensity to imitate and differentiate their normal methods of song is greatly exaggerated under the artificial state wherein they live when in confinement.

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April 30, 1904.

STANDARD TESTS OF AUDITION.*

IN a recent publication from this laboratory,† tests for acuteness of hearing were divided into two classes: speech-tests, which employ letters, words or sentences, spoken aloud or whispered, and mechanical tests, which employ such apparatus as the watch, the tuning fork and the acoumeter. The existence and the common use of these two methods, for similar purposes, seem to be explained by the fact that each method possesses peculiar advantages, while neither is sufficiently free from serious defects to give it the whole field. The method that employs the voice measures directly the most important function of audition, the hearing of human speech, and it may, at the same time, be made sufficiently complex to cover a wide range of tone and noise; but, to offset this advantage, the method suffers from the great variability of the vocal stimulus. Mechanical tests, on the other hand, are simpler and are more easily standardized; but they do not—just because of their simplicity—furnish an adequate and reliable expression of general

* From the Psychological Laboratory of Cornell University.

† See 'Auditory Tests,' B. R. Andrews, *Amer. Journal of Psych.*, XV., 14.

auditory capacity. An individual who hears with difficulty ordinary conversation may, nevertheless, pass a fair examination with the watch tick or the tuning fork.

There is no doubt that human speech, could it be definitely controlled, would furnish the most adequate and the most comprehensive means of determining auditory acuity. But there has always been the difficulty of standardizing so complex and so variable a thing as the spoken word. This difficulty is serious; for although speech has been somewhat widely employed for this purpose by physicians, otologists and school and army examiners, the want of a common unit of measurement makes it impossible to compare the results obtained. The results have, in consequence, only a local interest.

The first important step toward standardization—the careful compilation of standard test series, composed of a like number of representative phonetic elements—was taken by Mr. Andrews,* who likewise proposed, in the article cited, an improved method of procedure.†

The object of this note is to suggest a still further advance in the perfection of the speech test. Instead of employing directly the voice of the investigator, and instead of relying upon acoustic and organic conditions which vary from experimenter to experimenter and from place to place, it proposes to use permanent phonographic records, which can be copied an indefinite number of times and can be reproduced independently of local conditions. The phonograph is especially available at present, because recent improvements in construction provide hard, durable cylinders which are copies of a single master record. Thus it should be possible to reproduce in any place and under constant conditions the same test series, inscribed upon a single cylinder by a single voice.

Through the courtesy of the National Phonograph Company the writer has been permitted to make preliminary records at the company's works in Orange. These records have since been subjected to trial on an Edison phonograph in the Cornell laboratory.

In reproducing the series of test words it is necessary, of course, to control both pitch and intensity of the sound. Pitch is easily controlled by setting the phonograph at the rate used in inscribing the record (*e. g.*, 100 revolutions a minute of the cylinder). Intensity is controlled in two ways: (1) constancy of intensity is obtained by the use of the new 'model C' reproducer (Edison), whose writing point is held in the wax groove by a constant pressure automatically provided; (2) reduction of intensity is obtained by a device set into the rubber transmission-tube. The reducing device consists of two telescoping brass cylinders 15 cm. long. The outer cylinder is 1 cm. in diameter and is perforated with 35 holes of 4 mm. diameter, running from end to end in a spiral pattern. The inner cylinder has closed walls. When the two are pushed in together they form, therefore, a closed section of the transmission-tube; but as they are drawn gradually apart more and more of the 35 holes are uncovered, allowing a greater and greater escape of the sound. When all the holes have been exposed only a small fraction of the sound reaches the ear; when all the holes are again covered the tube is completely closed. Intermediate settings of the reducer (made by scale readings on the inner brass cylinder) give a wider range of intensities. To increase the range still further, stops are inserted in the smaller cylinder. The writer used three of these stops; one entirely closed, one with a circular aperture of 0.5 mm., and one with an aperture of 3.0 mm. diameter. The tests thus far made indicate that only two of the stops will be required. To avoid direct transmission of the sound, through the air, it is necessary either to place the phonograph in a partially sound-proof box or to conduct the transmission-tube through a wall or the key hole of a tightly-fitting door to a second adjoining room. It is only necessary that no sound be heard by the subject when the ear tubes are inserted in the ears but disconnected from the instrument. Several individuals can be examined at once by duplicating the ear tubes or by substituting a megaphonic horn for the

* *L. c.*, pp. 29–36 (final table of test words on page 36).

† *L. c.*, pp. 53 ff.

tubes. Both of these devices involve, however, some sacrifice of accuracy to rapidity. Whisper as well as conversation records have been used in our trial series. But the conversation records promise to give a more delicate measure of hearing than the others, and may eventually supplant the whisper series, which have, after all, been employed heretofore chiefly because they demand less floor space than the more intensive sounds of vocal speech.

It is worth noting that the number-words of the test disappear, as their intensities are gradually diminished by the setting of the reducer, as quite clear and well-defined sounds and not as blurred masses—an important point in an examination of this kind. The tests thus far carried out have been made with original—not molded—records. Should a sufficient demand arise, however, permanent master records could be provided.

A possible objection to the method proposed is that the control of the stimulus words, as regards both their quality and their intensity, falls short of the ideals of pure psychophysical work; but, in anticipation of this objection, it may be said that anthropometrical tests of capacity demand an entirely different standard of accuracy from psychophysical researches proper. The method suggested offers such evident advantages—in simplicity as well as in accuracy—over traditional methods, that it has seemed worth while to bring it to general notice.

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QUOTATIONS.

THE ATLANTIC CITY SESSION OF THE AMERICAN MEDICAL ASSOCIATION.

THE fifty-fifth annual session of the American Medical Association, held last week, was the most successful of any held in the history of the Association, not only in the number in attendance, but in the scientific work accomplished.

The attendance excelled that expected by the most hopeful. With the exception of one of the international medical congresses, it was probably the largest gathering of medical men ever held anywhere, the registration numbering 2,890. At the meeting in Atlantic City in 1900, 2,019 registered; at St. Paul in 1901, 1,806; at Saratoga Springs in 1902, 1,425; and at New Orleans in 1903, 2,006. Yet in spite of the number in attendance there was no evidence of crowding and no criticism in regard to accommodations. Atlantic City certainly proved herself capable of entertaining in a most satisfactory manner. The local committees of arrangement had done their work well, and are to be congratulated on the arrangements made and on the successful outcome of this magnificent meeting.

From a scientific point of view, no meeting ever surpassed it, whether we consider the meetings of special societies, international congresses, or what not. Every year some sections report having done very superior scientific work. This year from all the sections comes this report. It is not only the section officers and those especially interested in the sections who are saying this, but those who have never before taken an interest in the sections and who are more directly interested in other societies than in the sections of the American Medical Association are also acknowledging the superior scientific work at Atlantic City. The section officers deserve great credit for this result of their year's efforts. The officers of each section have vied with each other in trying to outdo what has been done in the past and to produce a program that should be superior scientifically to that of any preceding year and to that of any other special society. Those who know the amount of labor necessary to get up such a program and to make a section successful will appreciate that all the section officers have worked hard and have done their duty faithfully. They have all set standards for their successors that will be hard to surpass.

The symposia following the orations on Tuesday, Wednesday and Thursday evenings were something entirely new with this session, and they proved to be valuable as well as attractive. Never before have the general meetings been so well attended. The symposium on the first evening, which was devoted to a description of the research work that is being done in several institutions in this country,

was a revelation to those who did not know how much of this work was being done. The symposium on Wednesday evening, on the relation of the medical services of the Government to the profession, was also most interesting and instructive. Such a symposium tends to bring the profession and the services together as nothing else can. We all realize, to a certain extent at least, what the U. S. Public Health and Marine Hospital Service and the Medical Department of the Army have done and are doing, but we have been very unfamiliar with the work of the Medical Department of the Navy. Surgeon Stokes, in his part of the symposium, showed that the medical officer of the Navy has a wider field of usefulness than is usually supposed. The last symposium, that of Thursday evening, was also valuable and instructive, and brought to the attention of the profession other work that is being done by the government that is of special interest to medical men. While the building in which these meetings were held was a large one, standing room was at a premium on each occasion. President Musser deserves the thanks of the profession for having arranged for these symposia, and those who took part in them are also entitled to thanks for what they did to make them so successful.—*Journal of the American Medical Association.*

DEDICATION OF THE MEDICAL LABORATORIES OF THE UNIVERSITY OF PENNSYLVANIA.

THE dedication of the new medical laboratories of the University of Pennsylvania, which took place on Friday, June 10, constitutes an epoch in medical education in America. The ceremonies were dignified and simple, and were attended by a large number of physicians, principally members of the American Medical Association that had accepted the courteous invitation extended to them by the university to be its guests. A special train brought the visitors from Atlantic City and took them back at night. To those that had not previously visited Philadelphia, as well as to the old graduates of Philadelphia's medical schools, their visit to the university must have been a revelation. Dr. Horatio Wood, in his eloquent address at the dedication of the new laboratories, alluded to the magnificent material progress that the university has made in the last generation—a progress, one may add, in which Dr. Wood has been an important factor. The new laboratories are intended for the departments of pathology, physiology and pharmacology, and everything has been done to give these important departments an ideal home. The building is architecturally attractive, and is in harmony with the general plan of the newer buildings, especially the dormitories. Mr. J. Vaughn Merrick, in the absence of Dr. S. Weir Mitchell, the chairman of the medical committee, delivered the presentation address, to which Provost Harrison responded. Dr. H. P. Bowditch, professor of physiology at Harvard University, spoke for physiology, and emphasized the importance of the physiologic laboratory in medical instruction, although he did not fail to say a good word for didactic teaching, which must still have a place in the medical curriculum. It should be borne in mind, he said, that it is quite as possible to abuse the laboratory as the didactic method of instruction; and that in all schemes of education a good teacher with a bad method is more effective than a bad teacher with a good method. Professor R. H. Chittenden, director of the Sheffield Scientific School of Yale University, dwelt upon the importance of physiologic chemistry to medicine, and illustrated it by describing the epoch-making work of Hoppe-Seyler and his school. Dr. George Dock, professor of medicine at the University of Michigan, decried the tendency to magnify the place of the laboratory, and to encourage students to do advanced original work before the foundation is laid. He also spoke of the neglect into which pathologic anatomy has fallen, and urged the importance of performing autopsies whenever possible. The difficulty in regard to autopsies does not depend upon public sentiment alone, but upon a certain neglect upon our own part. He thought that as pathology gets everywhere out of cellars and back rooms and has a local habitation like the new laboratories, its cultivation would assume a broader and more independent character. The laboratory building is quadrangular in shape, two stories in height

above a high basement, and measures 340 feet front by nearly 200 feet in depth. All along the front are arranged small rooms for research, rooms for the professors and assistants, a library, etc.; these open into a private corridor, so that the men employed in these rooms may pursue their work without interruption from students passing through the main halls. The second floor is devoted exclusively to pathology. The entire north front of the building is devoted to laboratories for advanced students in pathology and pathologic bacteriology, and to the special research and assistants' rooms.—*American Medicine.*

BOTANICAL NOTES.

ADIRONDACK PLANTS.

MRS. ANNIE MORRILL SMITH publishes in the 'Adirondack League Club Year Book' a corrected and enlarged list of plants found on the Adirondack League Club Tract, in which are enumerated 455 species, distributed as follows: Lichens, 29; hepatics, 40; mosses, 82; ferns and their allies, 27; conifers, 11; flowering plants, 266. The nomenclature of the higher plants is that of Britton's 'Manual.' The list has been reprinted in a neat twenty-page pamphlet. The botanists of the club are to be congratulated upon this evidence of their activity in the field.

ALGAE IN WATER SUPPLIES.

GEORGE T. MOORE and Karl F. Kellerman, of the Division of Plant Physiology of the United States Department of Agriculture, have prepared a bulletin on the algae in water supplies which has been issued by the Bureau of Plant Industry (as No. 64). It appears that the investigation was first begun in order to find some cheap and practical method of preventing or removing the algal contamination of cress beds. This naturally extended to all cases of algal contamination of waters, including such growths in reservoirs in connection with water supplies for cities and towns. The importance of the matter is such that a preliminary publication is made in this bulletin in order that what has been found out as to preventives and remedies may be laid before boards of health and officers in charge of public water supplies.

It is here shown that 'it is entirely practicable to cheaply and quickly destroy objectionable algæ in small lakes, ponds, storage reservoirs and other similar bodies of water by the use of extremely dilute solutions of copper sulphate or of metallic copper.' Although copper sulphate is a poison it is to be used in such very dilute solutions as to render it harmless to man or other higher organisms. In the tests made in the cress beds it was possible to kill all of the algæ without injuring the cress, and still the solutions were so dilute that they were 'not considered injurious to man or other animals.'

The bulletin devotes some pages to the microscopical examination of drinking water, the wide distribution of trouble caused by algæ, the methods hitherto used for the abatement of the nuisance, the difficulties encountered, and then takes up the examination of the effects of various strengths of copper sulphate on different organisms. Among the organisms experimented with are *Chlamydomonas, Raphidium, Desmidium, Stigeoclonium, Draparnaldia, Navicula, Scenedesmus, Euglena, Spirogyra, Conferva, Closterium, Synura, Anabaena* and *Uroglena.* Some of these were killed in solutions as dilute as one part of copper sulphate to three million parts of water, while others endured solutions as strong as 1 to 2,000. It is evident that in order to apply this remedy the organisms must be fully known, and the authors emphasize the statement that it is impossible to tell what strength of solution to use without a thorough study of the organisms in any particular case. Incidentally they find that such treatment of the water supply is likely to destroy many pathogenic bacteria and also the larvae of mosquitoes.

STRUCTURE OF THE PLANT NUCLEOLUS.

HAROLD WAGER discusses the structure of the nucleolus of the cells of the bean (*Phaseolus*) in the January number of the *Annals of Botany,* and concludes 'that not only is the nucleolus concerned in the formation of the chromosomes, but that there is a definite morphological connection between them.' He says further that "it is found that the nucle-

olus is intimately connected with the nuclear reticulum; that it contains nearly all the chromatin of the nucleus; that this is transferred, previous to division, into the nuclear thread, which is then segmented into chromosomes; and that in the reconstitution of the daughter-nuclei, the chromosomes become fused into a number of more or less spherical or irregular masses which unite to form the daughter nucleoli."

NUMBER OF POLLEN GRAINS IN INDIAN CORN.

In the *American Naturalist* for December, 1881, the writer published a note giving the results of a large number of careful counts and estimates made a few years earlier as to the number of pollen grains produced by Indian corn (maize). Briefly, the results were as follows: Average number of stamens in a 'tassel,' 7,200; average number of pollen grains in an anther, 2,500; average number of pollen grains produced by a plant, 18,000,000.

A recent bulletin (No. 77) prepared by Professor P. G. Holden, of the Iowa Experiment Station, gives considerably higher results, the statement being that "careful counts made at this station last year of the number of pollen grains found in an ordinary anther taken from different parts of a great many tassels showed that between 49,000,000 and 50,000,000 pollen grains were borne on an average by each tassel."

THE EARLY FALLING OF BOX-ELDER LEAVES.

Every one who has watched the box-elder tree (*Acer negundo*) carefully has noticed that the first leaves to appear in the spring are by no means typical, often being simple, but deeply cleft, so as to resemble those of the maples, and never having more than three leaflets when compound. These cataphyllary leaves occur on the first and second nodes of the shoots of the season, and even on the third and fourth in extreme cases, gradually approaching the typical five-foliate compound leaves. Within a fortnight of the appearance of the first leaves, and shortly after the typical leaves have developed the cataphylla begin falling from the trees. When this defoliation is at its maximum the ground under large trees is covered with the discarded leaves, much as in the autumn. This is so marked that it is one of the objections to this tree on lawns and well-kept grounds. Why these leaves are discarded so soon is not plain. We are reminded of the discarding of the primary leaves of the pines, where the matter has gone so far that none of the first crop of leaves are retained. The streets of Lincoln, Nebr., which have many box-elder trees planted along their sides, are now (May 21) littered with these fallen cataphyllary leaves.

PHILIPPINE PLANT NAMES.

On request of Captain G. P. Ahern, Chief of the Forestry Bureau of the Philippine Islands, the botanist of the bureau, Mr. Elmer D. Merrill, has prepared a very useful 'Dictionary of the Plant Names of the Philippine Islands,' which has been published at Manila by the Department of the Interior of the Islands. It consists of two parts, the first of which is an alphabetical list of the native names with the corresponding scientific names, while the second list includes an alphabetical arrangement of the genera and species, with native synonyms and short explanatory or descriptive notes. The extent of the undertaking may be inferred from the fact that between 4,500 and 5,000 native names are enumerated. And yet the author himself calls attention to the fact that the present enumeration records the native names for 'perhaps twelve to fifteen of the seventy or eighty dialects spoken in the archipelago.' There is evidently much more work of this kind to be done, and Mr. Merrill is entitled to much credit for the excellence of his list as far as he has carried it.

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EXPEDITION FOR SOLAR RESEARCH.

With the aid of a grant of $10,000 from the Carnegie Institution, for use during the current year, the Yerkes Observatory of the University of Chicago has sent an expedition to Mt. Wilson (5,886 feet) near Pasadena, California, for the purpose of making special in-

vestigations of the sun. The principal instrument to be ercted on the mountain is the Snow horizontal telescope, recently constructed in the instrument and optical shops of the Yerkes Observatory as the result of a gift from Miss Helen Snow, of Chicago. This telescope is a cœlostat reflector, the cœlostat mirror having a diameter of 30 inches. A second plane mirror, 24 inches in diameter, reflects the beam north from the cœlostat to either one of two concave mirrors, each of 24 inch aperture. One of these concave mirrors, of about 60 feet focal length, is to be used in conjunction with a solar spectrograph of 5 inches aperture and 13 feet focal length; a spectroheliograph of 7 inches aperture, resembling the Rumford spectroheliograph of the Yerkes Observatory; and a stellar spectrograph provided wich a large concave grating, and mounted in a constant temperature laboratory. It is hoped that it will be possible with this stellar spectrograph to photograph the spectra of a few of the brightest stars. For fainter stars, the spectrograph is to be provided with several prisms, for use singly or in combination.

The second concave mirror of the cœlostat reflector is designed to give a large focal image of the sun, especially adapted for investigations with a powerful spectroheliograph and for spectroscopic studies of sun-spots and other solar phenomena. The focal length of this mirror is about 145 feet, so that it will give a solar image about 16 inches in diameter. The spectroheliograph for use with this large solar image is to be of 7 inches aperture and 30 feet focal length. For the present, until a suitable grating can be obtained, the dispersive train of this instrument will consist of three prisms of 45° refracting angle, used in conjunction with a plane mirror, so as to give a total deviation of 180°. The motion of the solar image, of which a zone about 4 inches wide can be photographed with the spectroheliograph, will be produced by rotating the concave mirror about a vertical axis by means of a driving clock. A second driving clock, so controlled as to be synchronous with the first, will cause the photographic plate to move behind the second slit. Three slits will be provided at this point, so as to permit photographs to be taken simultaneously through as many different lines of the spectra. It is hoped that this spectroheliograph will prove to be well suited for use with some of the narrower dark lines of the solar spectrum.

The work of the expedition is under the immediate direction of Professor George E. Hale, director of the Yerkes Observatory. During his absence Professor E. B. Frost will be in immediate charge of the Yerkes Observatory, with the title of acting director. Professor Frost will also be the managing editor of the *Astrophysical Journal*. Mr. Ferdinand Ellerman and Mr. Walter S. Adams will be associated with Professor Hale in the work on Mt. Wilson.

Professor G. W. Ritchey, superintendent of instrument construction at the Yerkes Observatory, will be in charge of an instrument shop which is being fitted up for the expedition of Pasadena.

CARNEGIE INSTITUTION OF WASHINGTON.

ON May 18, 1904, the trustees of the Carnegie Institution met, and after transacting the necessary business to provide for the transfer of all matters to the Carnegie Institution of Washington, a charter for which passed congress and was approved April 28, 1904, adjourned without day. The trustees named in the act met at once and reorganized under the new charter. The by-laws of the Carnegie Institution were adopted as the by-laws of the new organization, and the officers of the old organization were elected. General resolutions adopting all the obligations, etc., of the old institution were passed. Under the new charter no questions can be raised as to the competency of the institution to carry on the operations outlined in the deed of gift of the founder.

The executive committee of the Carnegie Institution of Washington met after the reorganization and practically completed the making of grants for the year 1904. It will greatly facilitate the work of the executive committee if all those thinking of making applications for grants for 1905 will have them in in September, as applications for grants for 1905 will then be taken up.

SCIENTIFIC NOTES AND NEWS.

Dr. Louis S. McMurtry, of Louisville, Ky., has been elected president of the American Medical Association for the meeting to be held next year at Portland, Ore.

Professor George Darwin, of Cambridge, will succeed Mr. Balfour as president of the British Association, and will preside over the meeting to be held in South Africa next year.

Professor Simon Newcomb has been elected corresponding member of the Berlin Academy of Sciences.

At its meeting on June 9, the Geological Society of London elected Professor J. P. Iddings, of Chicago, as a foreign member, while Dr. W. Bullock Clark, of Baltimore, and Hon. Frank Springer, of East Las Vegas, New Mexico, were elected foreign correspondents.

M. Henri Moissan, the eminent French chemist, has been elected a corresponding member of the Academies of Sciences of Vienna and Amsterdam.

Dr. C. S. Sherrington, professor of physiology in the University of Liverpool, has been elected a member of the Imperial Academy of Medicine, Vienna.

The Vienna Academy of Sciences has awarded its Baumgarten prize, of the value of about $800, to Professor Walter Kaufmann for his investigations on the theory of electrons.

The Liebig gold medal for distinguished services in applied chemistry of the Association of German Chemists has been presented to Dr. Rudolf Knietsch, of the Badische Anilin und Soda-Fabrik, the discoverer of the contact process of sulphuric acid manufacture.

At the forty-fifth general meeting of the German Engineers' Association the Grashof medal, instituted in honor of the founder of the association, was unanimously conferred on the two pioneers of steam turbine propulsion, the Hon. C. A. Parsons, of Newcastle-on-Tyne, and M. de Laval, of Stockholm.

At its recent commencement exercises the University of Pennsylvania conferred the doctorate of science on Russell Henry Chittenden, professor of chemistry at Yale University, and George Dock, professor of theory and practise of medicine at the University of Michigan; and the doctorate of laws on Sir Frederick Treves, the British surgeon; Henry Pickering Bowditch, professor of physiology in Harvard Medical School, and Dr. H. C. Wood, professor of therapeutics, materia medica and pharmacy at the University of Pennsylvania.

Princeton University has conferred the degree of doctor of science on Dr. Per Dusen, the naturalist of Rio de Janeiro, and the degree of master of arts on Mr. Gifford Pinchot, chief of the Bureau of Forestry.

The new chemical laboratory of the University of Utrecht, named in honor of Professor J. H. van't Hoff, has been formally opened. On the occasion Professor van't Hoff was given the honorary doctorate by the university.

M. Barrois has been elected a member of the Paris Academy of Sciences in the section of mineralogy in the room of the late M. Fouqué.

Professor Bashford Dean, of Columbia University, will attend the International Zoological Congress at Bern, and will visit a number of European museums.

Dr. G. Cantor has celebrated the twenty-fifth anniversary of his professorship of mathematics at Halle.

Professor J. Volhard, director of the Chemical Laboratory of the University of Halle, celebrated on June 4 his seventieth birthday.

Mr. Santos-Dumont has arrived in this country with his dirigible balloon in which he will take part in the St. Louis aeronautic competition.

Professor J. J. Thomson, of Cambridge, delivered the Robert Boyle lecture in the hall of Balliol College, Oxford, on June 3, his subject being 'The Structure of the Atom.'

In connection with the meeting of the American Medical Association at Atlantic City, there was organized a National Association for the Study and Prevention of Tuberculosis. Dr. E. L. Trudeau, of Saranac Lake, N. Y., was elected president.

AN International Association to combat Tuberculosis was opened at Copenhagen on May 26. Among the delegates were Lord Lister from England and Professor Brouardel from France.

M. HAMY, assistant astronomer at the Paris Observatory, has been appointed astronomer in the room of the late M. Callandreau.

THE Jardin des Plantes, Paris, has received from M. Eugéne Potron a legacy of $10,000 for the erection of a statue in honor of Bernardine de St. Pierre, at one time director of the garden.

FOR a memorial of the late Dr. George Salmon, to be erected in St. Patrick's Cathedral, Dublin, the sum of £430 has been subscribed. The proposal to place within the precincts of Trinity College a memorial of the late provost has also been cordially received.

WE record with regret the death of M. Léauté Sarrau, professor of mechanics in the Polytechnic School of the University of Paris and member of the Paris Academy of Sciences, on May 10; of Dr. Fedor Bredichin, professor of astronomy at St. Petersburg, at the age of seventy-three years; of Dr. Adolfo Cancani, professor of terrestrial physics in the University of Modena; of Dr. Karl Bopp, professor of physics at the Stuttgart Polytechnic School; and of Dr. Max Kaech, who a few months since went from Bâsle to accept the position of chief of the Geological Institute at Para, Brazil, where he contracted yellow fever.

THE herbarium of the late Professor Marc Micheli has been presented to the town of Geneva by his widow.

THE act of congress making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1905, contains the following: "The Secretary of Agriculture is hereby directed to obtain in the open market samples of seeds of grass, clover, or alfalfa, test the same, and if any such seeds are found to be adulterated or misbranded, or any seeds of Canada bluegrass (*Poa compressa*) are obtained under any other name than Canada bluegrass or *Poa compressa*, to publish the results of the tests, together with the names of the persons by whom the seeds were offered for sale." Announcement is made that the collection and testing of seeds as directed by this act will begin July 1, 1904.

WE learn from the London *Times* that only two days before the death of the late Mr. Jamsetjee N. Tata the government of India issued a *communiqué* to the press describing as 'absolutely without foundation' the assertion of certain newspapers that Mr. Tata's offer of property valued at £200,000 towards founding an institute of science had been rejected by the government. The *communiqué* points out that a year ago the government made financial concessions which cleared the ground of the pecuniary difficulties previously existing, and the principal question which remained under discussion was the procedure for the valuation of the trust property. The government of Bombay has recently been communicated with as to the progress made in this and other essential preliminaries, and when these have been carried out the needful legislation will be introduced. So far from having rejected Mr. Tata's offer, the government of India have promised a large subsidy to the scheme, and they have throughout the negotiations 'done everything within their power to facilitate the progress and to aid the realization of a project which has their fullest sympathy." In its detailed memoir of Mr. Tata, the *Times of India* says that there is every probability that the scheme will sooner or later come into force, but, in case it did not, it was Mr. Tata's intention to divert the proposed endowment to another trust, which would enable Indian students to proceed to Europe to qualify for the Indian civil and other services and for the electrical and engineering professions until such time as it became possible, with the proper aid of government, to start the research institute as originally planned.

Nature states that at a sale recently held by Mr. Stevens in King Street, Covent Garden, a great auk's egg in fine condition was sold for two hundred guineas, the purchaser being Mr. Pax. This is a considerable fall-

ing-off from the three hundred guineas obtained for the last specimen sold by Mr. Stevens, the reason being attributed to the fact that several other fine examples are in the market. Mr. Pax's specimen was originally bought for two sovereigns. The next highest price obtained at the recent sale was £8 18s. 6d. for a clutch of four eggs of Bonaparte's sandpiper. For a single egg, the highest price was 27s. 6d. for one of Pallas's sand-grouse.

The annual return showing the number of experiments performed in Great Britain on living animals during the year 1903 has been issued as a parliamentary paper. According to the abstract in the London *Times* the total number of licensees was 347, of whom 97 performed no experiments. Evidence is afforded showing that licenses and certificates have been granted and allowed only upon the recommendation of persons of high scientific standing; that the licensees are persons who, by their training and education, are fitted to undertake experimental work and to profit by it; and that all experimental work has been conducted in suitable places. The total number of experiments was 19,084, being 4,178 performed with anesthetics and 16,913 without, more than in 1902. Of the total, 2,171 were anesthetics. In no case was a cutting operation more severe than a superficial venesection allowed to be performed with anesthetics. The experiments performed without anesthetics were mostly inoculations; a few were feeding experiments, or the administration of various substances by the mouth, or the abstraction of a minute quantity of blood for examination. In no instance was a certificate dispensing with anesthetics allowed for an experiment involving a serious operation. Operative procedures performed without anesthetics were only such as were attended by no considerable pain. In a very large number of such experiments the results were negative and the animals suffered no inconvenience from the inoculation. The usual inspection of registered places found the animals everywhere well lodged and cared for. Only two irregularities were reported.

UNIVERSITY AND EDUCATIONAL NEWS.

At the recent commencement exercises of Columbia University a gift of $250,000 from Mr. Lewisohn was announced, to be used for a building for the School of Mines.

The sum of $325,000 has been collected for MacAlaster College in Minnesota. The largest gifts were $100,000 from Mr. C. D. Dayton and $50,000 from Mr. J. J. Hill.

A new physiological laboratory, erected at a cost of $125,000, has been opened at the University of Vienna.

President E. A. Alderman, of Tulane University, has been elected president of the University of Virginia. The University of Virginia, in accordance with the democratic ideas of Jefferson, has hitherto been governed by a board of visitors and the faculty without a president.

The removal of Professor John Dewey from the University of Chicago to Columbia University has led to certain changes in the department of philosophy and education at Chicago. Psychology has been made a separate department, with Professor James R. Angell at the head, and Professor James H. Tufts has been promoted to the head of the department of philosophy. It is further reported that Mr. John H. Locke will be made head of the School of Education.

Professor J. W. Gregory, of Melbourne, and formerly of the British Museum, has been elected to the chair of geology at Glasgow University.

Mr. F. G. Donnan, Ph.D., lecturer in chemistry in the Royal College of Science, Dublin, has been appointed to the Brunner chair of physical chemistry in the University of Liverpool.

The council of the University of Birmingham has conferred the honorary title of professor of geography on Mr. W. W. Watts, M.A., F.R.S., assistant professor of geology.

The University of Vienna has officially recognized work in radiology in the medical faculty. Dr. Leopold Freund, Dr. Robert Kienböck and Dr. Guido Holzknecht have been appointed docents in the subject.

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